ABSTRACT

Pneumatic actuation system offers an attractive alternative to hydraulic and electromechanical actuation systems for low to medium power requirements. However nonlinearity-contributing factors like air compressibility, airflow through orifice, friction and externally applied load variation make position control of pneumatic actuators difficult vis-à-vis that of hydraulic and electromechanical actuation systems. The availability of low-cost, high-performance computer processors has enabled pneumatic servo systems to take advantage of advanced control algorithms in industrial applications. For nonlinear systems fuzzy logic controllers provide a feasible alternative as they can capture the qualitative aspects of human reasoning and decision-making processes. The objective of this research is to explore fuzzy logic based control of pneumatic actuator for positioning the piston at different linear displacements under variable loading conditions, so as to control amplitude and duration of transient oscillations as well as magnitude of steady state positional error.

A comprehensive mathematical model has been utilized to develop a virtual model of the pneumatic actuation system. The virtual model developed provides features in consonance with the quantitative mathematical model and further it is in the form of a generalized model. The functional knowledge of various predominant parameters of pneumatic servo system has been obtained by shortlisting and optimizing the control parameters. A knowledge building exercise has been conducted by simulating the dynamic behaviour of the pneumatic servo system by segmenting the total piston displacement and applied payload. The knowledge of the parameters affecting the performance characteristics of the pneumatic servo system has been utilized for designing a fuzzy logic controller. The fuzzy logic controller has been further tuned by applying expert knowledge of the dynamic behaviour of the pneumatic servo system. The control performance of the fuzzy logic controller has been evaluated quantitatively. For the fuzzy logic control system the analysis of transient response reveals improvements both in terms of amplitude and duration of oscillations for all operative conditions. Also, the steady state positional error for low to medium linear displacements and different payloads provided encouraging results, wherein the
magnitude of the positional error gets marginalized to a greater extent, but it is exhibiting relatively more steady state positional error for high linear displacements.

**Keywords:** Pneumatic actuation system, fuzzy logic control, Adaptive Neuro-Fuzzy Inference System (ANFIS), Integral of Absolute Error (IAE), MATLAB and Simulink